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Sensitivity of flow harmonics to sub-nucleon scale fluctuations in heavy ion collisions

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Event by event hydrodynamic simulations of AA and pA collisions involve initial energy densities with large spatial gradients. This is associated with the presence of large Knudsen numbers ($K_n \sim 1$) at early times, which may lead one to question the validity of the hydrodynamic approach in these rapidly evolving, largely inhomogeneous systems. A new procedure to smooth out the initial energy densities is employed to show that the initial spatial eccentricities, ε_n , are remarkably robust with respect to variations in the underlying scale of initial energy density spatial gradients, λ . For $\sqrt{s} = 2.76$ TeV LHC initial conditions generated by the MCKLN code[1], ε_n (across centralities) remains nearly constant if the fluctuation scale varies by an order of magnitude, i.e., when λ varies from 0.1 to 1 fm. Given that the local Knudsen number $K_n \sim 1/\lambda$, the robustness of the initial eccentricities with respect to changes in the fluctuation scale suggests that the v_n 's cannot be used to distinguish between events with large K_n from events where K_n is in the hydrodynamic regime. We use the 2+1 Lagrangian hydrodynamic code v-USPhydro[2] to show that this is indeed the case: anisotropic flow coefficients computed within event by event viscous hydrodynamics are only sensitive to long wavelength scales of order $1/\Lambda_{QCD} \sim 1$ fm and are incredibly robust with respect to variations in the initial local Knudsen number (see [3]). This robustness can be used to justify the somewhat unreasonable effectiveness of the perfect fluid paradigm in heavy ion collisions.

[1] H.J.Drescher and Y.Nara,Phys.Rev.C75,034905 (2007).

[2] J.Noronha-Hostler, et. al, Phys.Rev.C88,044916 (2013); J.Noronha-Hostler, J.Noronha and F.Grassi,Phys.Rev.C90,no.3,034907(2014).

[3] J.Noronha-Hostler,J.Noronha,M.Gyulassy,“The unreasonable effectiveness of hydrodynamics in heavy ion collisions”,to appear.

On behalf of collaboration:

NONE

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